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Armstrong's ACOUSTICAL PRODUCTS

CORKOUSTIC .....CERAMACOUSTIC

for

acoustical correction of churches, auditoriums, and theatres, and noise-quieting of banks, schools, hospitals, offices, Sunday School rooms, factories, and other public buildings

Armstrong's (A) *Product*

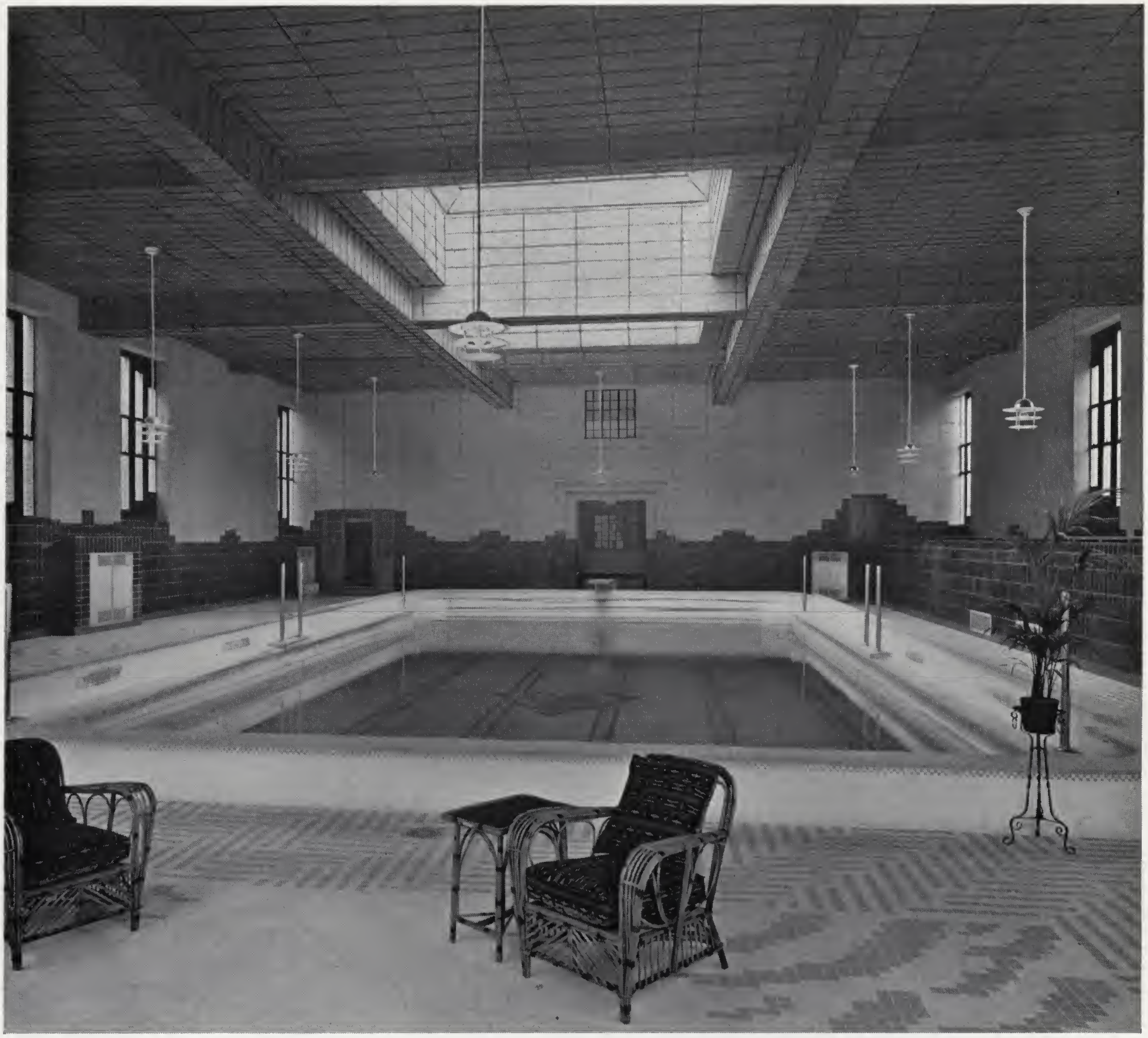
QUICK REFERENCE GUIDE

Armstrong's
Acoustical Products

CORKOUSTIC
CERAMACOUSTIC

Armstrong's (A) *Product*

Armstrong Cork & Insulation Company
LANCASTER PENNSYLVANIA



ABOVE—*Swimming pool din was subdued in the Sports Building at the College of New Rochelle, New Rochelle, New York, with Corkoustic Type A. Condensation and ceiling drip, necessitating frequent cleaning, also have been eliminated. Architect — Henry J. McGill, New York.*

LEFT—*Another view of the attractive swimming pool at the College of New Rochelle.*

SOUND BECOMES A SCIENCE

Early 20th century research develops possibilities of acoustical correction

BEFORE 1900 practically no constructive steps were taken toward the correction of bad acoustical conditions in auditoriums, churches, theatres, banks, schools, and other public buildings. This was true even though the existence of acoustical defects in such structures was recognized on every hand. Lack of progress was due to the fact that little was known of the science of acoustics. Certain haphazard "remedies," such as the stringing of tense wires across a room, were used but results were naturally not forthcoming.

About 1900, after some years of consistent research, the late Professor Wallace C. Sabine, of Harvard University, began the publication of his findings. At last the way was pointed toward a true understanding of acoustics and the correction of acoustical defects. The momentum supplied by Professor Sabine turned the attention of a number of very competent physicists, both in this country and abroad, to the subject of architectural acoustics. The results of their combined research give us a means of determining, in advance of construction, exactly what the acoustical conditions of a room will be and a means of calculating the necessary steps to be taken in eliminating acoustical defects.

Beauty can be served

THE science of acoustical correction, at the point to which it has now been developed, relieves the architect of many of the limitations of design imposed by the old ideas of what was necessary for good acoustical conditions. The copying of structures known for their good acoustics is no longer necessary. Proportion need not be sacrificed, nor beauty disregarded. With the methods and materials described in this book, an auditorium or room of any design, within reasonable limits, can be made acoustically satisfactory.

Acoustical Materials Available

AFTER considerable time spent in research and testing, the Armstrong Cork & Insulation Company has developed four acoustical products, offering architects and builders a special material for every need in the acoustical and noise-quieting field.

Armstrong's Acoustical Products, covering a range of absorption from 32 per cent to 82 per cent, at a frequency of 512, are: Corkoustic Type C which has a pleasing light color when left unpainted; Corkoustic Type B which provides a rich warm brown surface for rooms that need dignity; Corkoustic Type A, a satisfactory and economical material for use where large areas are to be treated; and Ceramacoustic, a fireproof material made of inorganic matter and possessing exceptionally high efficiency.

Complete descriptions of these products appear elsewhere in this booklet. The intervening pages cover a brief study of the science of acoustics, together with such data, charts, and methods as are necessary to easily calculate the amount of absorption needed for any room.

Three phases of acoustics

ACOUSTICS as considered herein is divided into two distinct phases; namely, (A) acoustical correction (B) noise-quieting.

Acoustical correction is necessary and desirable in churches, auditoriums, halls, theatres, and similar rooms where conditions

must necessarily be such that speech and music can be transmitted clearly and distinctly to the audience. When it is considered that the main requirement in such structures is the correct hearing of the sounds of voice and music on the part of the audience, it cannot be denied that anything which detracts from the ease with which this is done is a serious shortcoming. Here acoustical correction is known as acoustical treatment—the scientific placing of enough acoustical material to make hearing conditions ideal.

Noise-quieting is the other phase of acoustical engineering. This is important for the treatment of schools, hospitals, Sunday School rooms, swimming pools, banks, offices, shops, workrooms, factories, and the like—in short, all places where workers are subjected to noisy surroundings. The need for sound control in such places is startlingly revealed by research. Mr. Clifford Melville Swan in the Architectural Forum says: "Medical science informs us that there is a chemical and physiological action produced in the nervous system by prolonged exposure to noise, and that the resultant fatigue may go so far as to even cause collapse."

There is another phase of acoustics which deals with the transmission of sound into buildings, from one room to another, or from one part of a structure to an adjacent part. This is a separate study and this phase of acoustics is not dealt with in this booklet.

Distracting sound is barred from the auditorium of the Westminster Presbyterian Church, Decatur, Illinois, where the ceiling is attractively treated with Armstrong's Corkoustic. Here a pleasing effect has been secured with a stencilled design. Architects—Brooks, Bramhall, and Dague, Decatur. General Contractor—Roy W. Christy.

Noise hinders working efficiency

AN interesting and valuable series of tests to determine the effects of noise on working efficiency was conducted by Dr. Donald A. Laird of Colgate University, and reported by him in the Journal of Industrial Hygiene. Dr. Laird found that 19% less energy was consumed by a typist when working under quiet rather than noisy conditions. He found that the rapidity of work also was affected, there being an increase of 7.4% in speed in the case of the most rapid typist when in quiet surroundings.

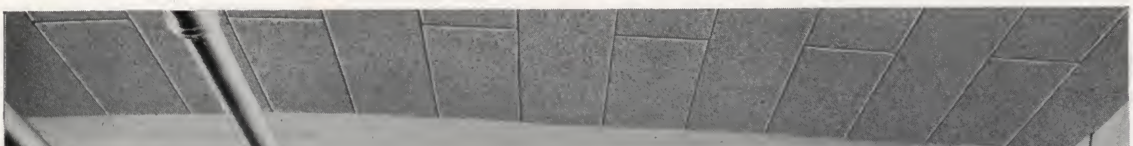
All the evidence that science has gathered points out that reduction of noise around workers is an economical move and one whose cost will be more than repaid by increased efficiency. Better working conditions can be secured by applying acoustical material to subdue unwanted noise.

Progress in noise abatement

MANY laws have been passed by city governments, regulating and eliminating noise nuisances wherever possible. The first commission to be formed under these laws was the Noise Abatement Commission of New York City. This commission, realizing that noise affects the physical and mental well-being of city workers, recommends:

Proper treatment of wall surface and spaces between walls and proper selection of room furnishings to increase sound absorption and reduce sound transmission. To diminish the cost, it is recommended that such treatment, if possible, be included in the original designs.

Absorptive pads under the base of machines to isolate and prevent transmission of sound and vibration to other parts of the structure also are recommended.



Corkoustic applied to the ceiling of the R. C. A.—Victor Corporation General Office, at Boston not only absorbs office noises but serves as an insulation to keep this top floor cool in summer and warm in winter.

SOUND . . . HOW IT ACTS

SOUND is a wave motion in the atmosphere caused by a series of compressions and rarefactions incident upon the vibration of any body. The amplitude of audible sound waves is small, varying, according to the accepted authorities, from 0.00000005 inch for a scarcely audible sound to 0.004 inch for a loud sound. Sound waves travel with great speed, varying with the media through which they are transmitted. Through air, sound travels at the rate of 1,088 feet per second. The speed is much greater for denser mediums, reaching 16,360 feet per second through steel.

In the study of architectural acoustics, we are chiefly concerned with the action of sound as it strikes various surfaces, for acoustics largely depends upon the effect which the exposed materials in walls and ceilings have upon sound waves. Figure No. 1 illustrates what happens when a sound wave strikes a surface. The incident sound strikes the material as indicated. A certain amount of sound is at once absorbed by the material (A). Another fraction is transmitted through (T), and the remainder is reflected into the air (R). The amount of sound that is reflected, transmitted, and absorbed varies widely, depending upon the nature of the material and its surface.

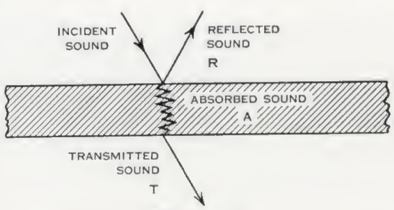


*Figure 1

**Prof. F. R. Watson, University of Illinois "Acoustics of Buildings"*

Sound is reflected

AS that portion of the sound which is reflected from the surface of the material and is thrown back into the air, it proceeds on its path until it strikes another surface. Then a portion is reflected again and a reverberation set up. This continues until the energy of the sound wave is all consumed by the absorption and transmission of the materials which it strikes. When it is considered that if sound waves strike a smooth plaster wall of sufficient rigidity, 97% of the sound is reflected, the reason for sounds of long duration after the initial transmission becomes plainly evident.

But sound can be absorbed

THE absorption of sound is the basis of acoustical correction. By increasing or decreasing the amount of absorbing material which the sound waves will strike, almost any duration of sound can be secured.

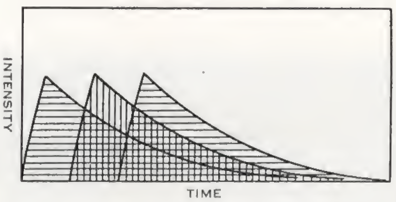
In order to work intelligently with sound absorption it becomes evident at once that a measure of absorbing power is necessary. For this purpose scientists have agreed upon the use of the open window as a standard. One square foot of open window, through which all sound would pass without resistance, or be completely "absorbed" is therefore regarded as unity. A material then that is given an absorption factor of 0.10 absorbs 10% of the sound that strikes it.

Every material and furnishing exposed in a room absorbs a certain amount of sound. Draperies, upholstering, clothing, rugs, furniture—all are sound absorbers to a greater or lesser degree. The table on page 10 gives the sound absorbing value of the common building materials and furnishings as determined by laboratory tests by recognized authorities.

WHEN SOUND BECOMES ANNOYING

BY FAR the most common acoustical defect is excessive reverberation. This condition results when sounds are prolonged by reflection so that they overlap sounds created later, giving rise to difficulty in distinguishing the separate sounds. If, as in a typical case, sounds persisted for five seconds and new sounds were being created at the rate of three per second, fifteen separate sounds would be in the air at the same time. As a result, distinctness of sound impression is lost and the listener hears a jumble of noises instead of separate intelligible sounds. This condition is illustrated by Figure No. 2, below.

Figure 2. *Sounds in an acoustically incorrect room arise so rapidly in intensity and extend so long that overlapping results.*



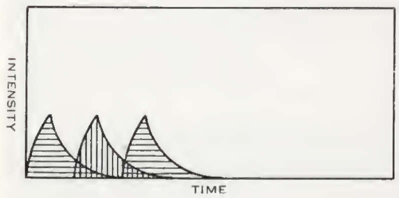


Figure 3. *Same sounds as above in an acoustically correct room. Note change of form of the individual sounds and how this minimizes overlapping.*

It is obvious that the solution of the problem is to reduce the duration of the individual sounds, to secure an effect such as that illustrated by Figure No. 3, above. This is accomplished by introducing into the rooms materials which will absorb the sound soon enough to prevent excessive reverberation. It is upon this basis that the modern science of acoustical correction proceeds.

While it is reverberation that causes the principal troubles in connection with acoustics, there are also a number of more specialized acoustical defects that sometimes occur in rooms of complicated character. The cause and nature of the main types are described below.

Echoes can be eliminated

SECOND in importance to reverberation as an acoustical defect is echo. Echoes are caused by sound reflection at a point far enough away from the listener to send back a complete repetition of the sound which he has previously heard by direct transmission. Echoes start when the difference between the time of reception of the direct and reflected sound is approximately one-sixteenth of a second. Translated into terms of space this corresponds to a difference of about sixty feet between the paths of the direct and reflected sounds.

The ceiling of this private office has been treated with Ceramacoustic to insure a quiet atmosphere. This new acoustical product is exceptionally efficient, has a high light reflection value, is furnished pre-painted at the factory, and is absolutely fireproof.

Echoes can be eliminated by covering the reflecting wall with a material that will absorb a sufficient amount of sound to dissipate and scatter the wave that would otherwise be reflected, or by changing the angle or shape of the reflecting surface. The first method is, of course, the most desirable for it does not involve the sacrifice of design.

"Loud spots" can be softened

IN certain types of auditoriums, particularly those in which concave areas are present, there are places where the sound is too intense to be pleasant. These places constitute the third type of acoustical defects. They are the result of sounds being concentrated by reflection into a small area. The curved reflecting surface creates a condition at the center of curvature, much the same as a convex lens concentrates light.

These "loud spots," or sound foci, are also created by other than curved areas. Whenever reflecting walls are so arranged that a number of reflections of the same sound are brought together simultaneously a "loud spot" results.

No need for "dead spots" or interference

IN certain acoustically incorrect auditoriums, observers note that there are places where sound emitted on the stage is scarcely audible. These places are called "dead spots." They result from a condition exactly opposite to that which is responsible for sound foci. They are the points where the sound waves, due to the angle at which they are reflected from the walls and ceiling, do not reach. This condition, like the other acoustical defects can be eliminated by the intelligent diffusion of sound.

Addresses and music can be heard clearly in the above auditorium treated with Corkoustic Type C, the new material with the light color of natural cork. A pleasing decorative effect was secured by combining painted and unpainted panels. Painting with Armstrong's Acoustic Paint does not affect sound-absorbing efficiency. Since all types of Corkoustic are made of cork they provide high insulating value.

SOUND CAN BE CONTROLLED

SOUND, after it is emitted, proceeds outward in spherical waves until the walls and ceiling are reached. There the sound waves are partly reflected, partly absorbed, and partly transmitted by the materials they strike. The reflected sounds follow the same procedure, rapidly filling the room with sound. The sound builds up to its maximum intensity, strikes a moment of equilibrium, and then dies away as the energy of the waves is absorbed or transmitted. Fortunately this amount can be determined mathematically. On the next page the method of doing this, together with all the necessary working data, is given. This method, if accurately followed, will prove a reliable guide to acoustical correction in all ordinary rooms. As successive sounds are created in a room where good acoustical conditions do not prevail, the separate sounds overlap, as shown in Figure No. 2. The cross-hatched areas, representing the overlapping of the sounds are far too great for good hearing.

No overlapping noticed

WHEN the sounds rise to their maximum intensity rapidly and then die away quickly, the sound form becomes such that overlapping is reduced to the point where the listener is not conscious of it. Figure No. 3 illustrated such a condition. It is achieved by having in the room enough sound-absorbent material to reduce the length of time it takes for the sound to reach maximum intensity and to absorb it quickly after that point. If too much absorbing material is present, the sound dies out before reaching full volume. It is at the happy medium between too little and too much absorption that the ideal acoustical condition results.

Optimum time of reverberation

THE time of reverberation which gives the best acoustical results is called the "optimum time of reverberation." It varies for different types of sound, being lower for speaking than for music. For practical purposes, however, an average which allows for satisfactory hearing for both types of sound is best used. This may be determined from the chart on page 11, Figure 4. The optimum period of reverberation should be calculated with two-thirds of the audience present. However, it is often necessary to calculate the optimum period of reverberation with one-half or less of the audience present when the auditorium is used more frequently for smaller audiences. A low period of reverberation, while making a room slightly dead for music alone, improves the hearing conditions for speech.

Swimming meets are enjoyed in the natatorium of the University of Rochester, N. Y., because excessive reverberation has been reduced to a minimum by a ceiling of Corkoustic. Architects—Gordon & Kaelber, Rochester. Contractor—A. W. Hopeman & Sons, Rochester.

HOW TO CONTROL SOUND

SINCE the amount and kind of sound-absorbent material in a room is the governing factor in the time of reverberation, the consideration of the necessary amount of sound-absorbing material to be added to that already in the room is the point of major importance.

Simply stated, the method of arriving at the needed acoustical correction is this: first, it is determined how many absorbing units are needed to secure the desired optimum time of reverberation. Absorbing units already in the room are subtracted and the remainder represents a deficiency to be made up by installing an acoustical material.

The formula developed by the late Professor Sabine for determining the absorption necessary to secure the optimum time of reverberation is: $t = .05\ V/a$

In this formula, (t) is the optimum time of reverberation in seconds, .05 is a constant, (V) is the volume of the room in cubic feet and (a) is the number of absorbing units.

In the use of this formula (t), the desired optimum time of reverberation, for auditoriums, theatres, public buildings, and like places can be secured from the chart on page 11, Figure 4. The optimum time of reverberation on which this chart is based is a compromise between the higher optimum time for music and the lower optimum time for speech. For offices, shops, and places where the object of acoustical correction is to deaden sound, a somewhat lower optimum time of reverberation is desirable.

To determine the amount of absorption already in the room, the values may be taken from the following table:

Table 1. Sound Absorption Coefficients

**Armstrong's Corkoustic Type A, 1½ inches thick	per square foot	.32
*Armstrong's Corkoustic Type B, 1½ inches thick	per square foot	.61
*Armstrong's Corkoustic Type C, 1½ inches thick	per square foot	.61
*Armstrong's Ceramacoustic, 1½ inches thick	per square foot	.82
*Armstrong's Ceramacoustic, 1⅛ inches thick, unpainted	per square foot	.64
*Armstrong's Ceramacoustic, 1⅛ inches thick, spray painted four coats	per square foot	.62
*Armstrong's Temlok, ½ inch thick	per square foot	.27
Brick wall, 18 inches thick	per square foot	.032
Brick wall, painted	per square foot	.017
Brick, set in portland cement	per square foot	.025
Carpets, unlined	per square foot	.15
Carpets, lined	per square foot	.20
Carpets, heavy with lining	per square foot	.25
Carpet rugs	per square foot	.20
Cheesecloth	per square foot	.019
Concrete	per square foot	.015
Cork tile flooring	per square foot	.03
Cretonne cloth	per square foot	.15
Curtains, chenille	per square foot	.23
Curtains, in heavy folds	per square foot	.5 to 1.0
Glass, single thickness	per square foot	.027
Linoleum	per square foot	.03
Marble	per square foot	.01
Oil paintings, including frames	per square foot	.28
Open window	per square foot	1.00
Opera chairs:		
(a) plywood seat and back, no upholstery	per square foot	0.24
(b) padded back and seat, covered with pantasote (imitation leather)	per square foot	1.6
(c) various paddings, covered with velour or mohair	per square foot	2.3 to 3.5
Oriental rugs, extra heavy	per square foot	.29
Plaster on wood lath	per square foot	.034
Plaster on wire lath	per square foot	.033
Plaster on tile	per square foot	.025

*From tests made by U. S. Bureau of Standards. **From tests made by F. R. Watson and Vern O. Knudsen.

All other figures are taken from those published in Watson's "Acoustics of Buildings."

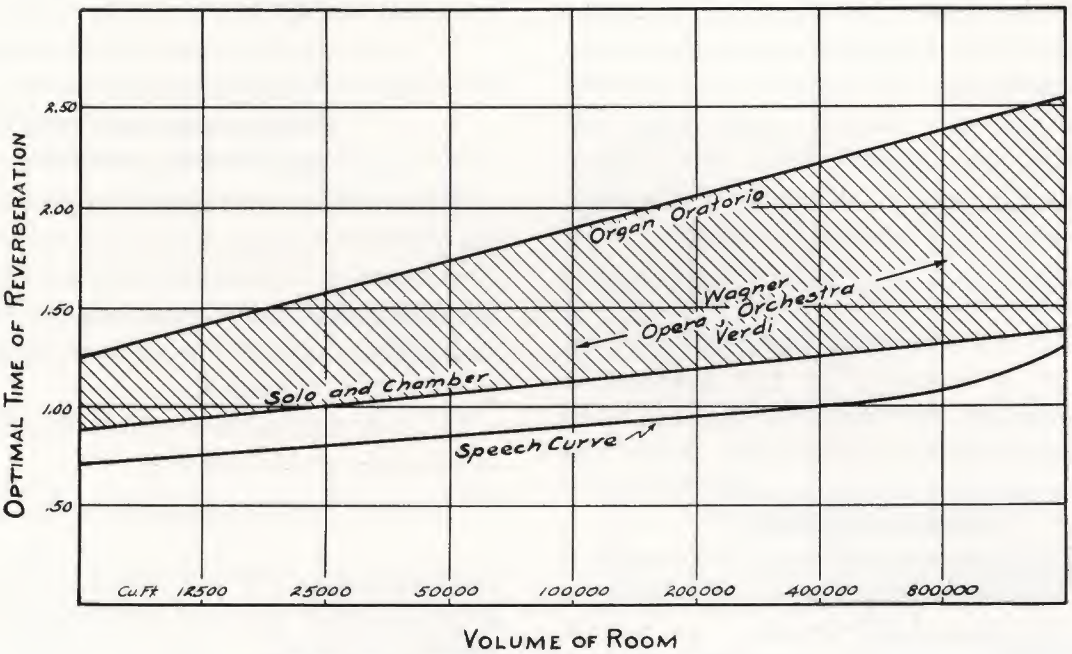


Fig. 4. Chart showing optimal times of reverberation.
Courtesy—Journal of the Acoustical Society, Vern O. Knudsen.

To determine the correct acoustical condition of a room

LET us suppose that an auditorium is 60 feet wide by 100 feet long by 20 feet high. The floor is concrete, the walls are plaster on tile, and the ceiling is plaster on metal lath. There are 500 square feet of window glass and 525 seats.

The optimum time of reverberation is desired when 350 people are present. (Calculations must be made on the basis of an average audience of a definite number, for persons absorb sound and varying audiences affect the conditions. A two-thirds audience is generally used for the purpose of calculation.)

Volume = 120,000 cubic feet

From figure No. 4, giving the optimum time of reverberation: t = about 1.10 to 1.70 seconds. The absorption already in the room is calculated as follows from the table of values of common building materials appearing in table No. 1 on page 10:

Surface	*Material*	*Area*	*Coefficient*	*Units*
Floor	Concrete	6,000	.015	90
Windows	Glass	500	.027	14
Walls	Plaster on Tile	5,900	.025	148
Ceiling	Plaster on Lath	6,000	.033	198
Empty Seats	Wood	525	.24	126
For room untreated and empty.................... a_1				= 576
Ceiling	1½″ Corkoustic, Types B and C	6,000	(.61 − .033)*	+3460
For room treated and empty.................... a_2				= 4036
Audience	350 persons		(4.0 − .24)	+1316
For room treated and occupied.................... a_3				= 5352

Substitute these different values of "a" in the formula:

$$t = \frac{.05V}{a}$$

Untreated and Empty

$$t = \frac{.05V}{a_1} = \frac{.05 \times 120000}{576}$$

t = 10.4 seconds

Treated and Empty

$$t = \frac{.05V}{a_2} = \frac{.05 \times 120000}{4036}$$

t = 1.48 seconds

Treated and Occupied

$$t = \frac{.05V}{a_3} = \frac{.05 \times 120000}{5352}$$

t = 1.12 seconds

*Absorption of plaster surface.

It will be noted that the time of reverberation of the treated room ranges from 1.48 seconds for the empty room to 1.12 seconds for the treated room with 350 persons in the audience. Since these points lie within the range of the curve in Figure 4, the quantity of treatment is correct.

To calculate the reduction in noise level

WHEN an acoustical material is to be used in a room for the purpose of noise-quieting, we find it necessary to answer the question as to how much the

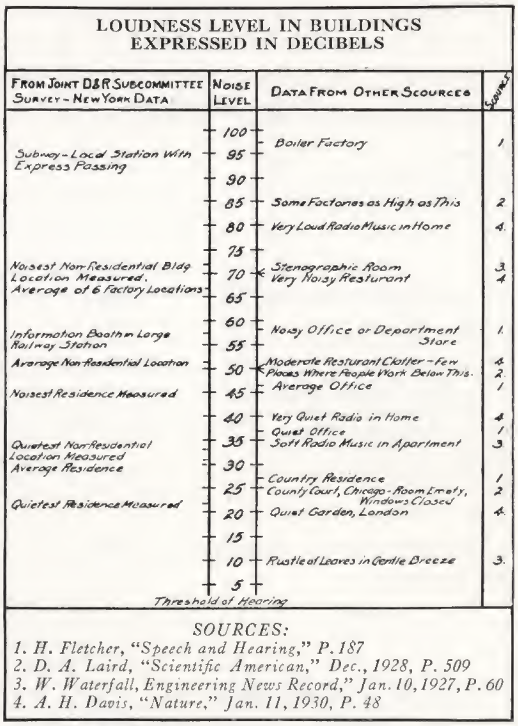


Figure No. 5. *Noises in Buildings (Journal of Acoustical Society 2-63, 1930)*

noise level will be reduced. We are indebted to the United States Bureau of Standards for a means of calculating the amount of the reduction by formula:

$$L_1—L_2 = 10 \text{ Log}_{10}\ a_2/a_1$$

Where L_1 and L_2 = Intensities of sound measured in decibels as heard by the ear, corresponding to the total absorption values a_1 and a_2.

a_1 = Number of units of absorption in the room before treatment.

a_2 = Number of units of absorption in the room with sound-absorbing material installed.

The ear does not respond in proportion to the physical energy which falls upon it, but the sensation of loudness follows a logarithmic law. Thus with intensities of 10, 100, and 1000, the ear would hear in the proportion of 1, 2, and 3.

We will assume a room of the following dimensions to be treated:

60′ long x 45′ wide x 12′ high with 6 windows 4 x 8

First calculate the absorption of the room as it is, empty and without treatment:

Surface	*Material*	*Area*	*Coefficient*	*Units*
Ceiling	Plaster on Lath	2,700	.033	89
Floor	Linoleum	2,700	.03	81
Walls	Plaster on Tile	2,520	.025	63
Windows	Glass	202	.027	5
			a_1 =	238

Then calculate the absorption for the room after Corkoustic has been installed:

Surface	*Material*	*Area*	*Coefficient*	*Units*
Ceiling	Corkoustic	2,700	.61	1647
Floor	Linoleum	2,700	.03	81
Walls	Plaster on Tile	2,520	.025	63
Windows	Glass	202	.027	5
			a_2 =	1796

Substitute in formula:

$$L_1—L_2 = 10 \log_{10} a_2/a_1$$
$$L_1—L_2 = 10 \log_{10} 1796/238$$
$$= 10 \log_{10} 7.55$$

Look up $\log_{10}$ 7.55 in table of logarithms:

$$L_1—L_2 = 10 \times .878$$
$$L_1—L_2 = 8.78 \text{ decibels reduction}$$

When the small private office is separated from the main office by a glass or other partition, this partition should extend from floor to ceiling. The entire ceiling area should be treated as indicated by the heavy dotted line.

Figure No. 6 represents graphically the formula:

$$L_1 - L_2 = 10 \log_{10} a_2/a_1$$

From this curve, knowing the ratio of absorption after treatment to the absorption before treatment, we are able to find the loudness reduction. For example:

It is found from calculations that a room has 200 units of absorption without treatment:

$$a_1 = 200$$

Let 800 units of absorption be added by introducing some sound absorbent material, making:

$$a_2 = 1000$$

Then:

$$a_2/a_1 = 1000/200 = 5$$

From the curve of figure No. 6, for a value of a_2/a_1 equal to 5, we find 7 decibels of noise reduction. It must be remembered, however, that this formula and curve are based on average loudness conditions. The actual effect on a single person will depend to an extent on the distance between this person and the source of sound.

It will be observed that the curve begins to flatten out at about 5 decibels indicating

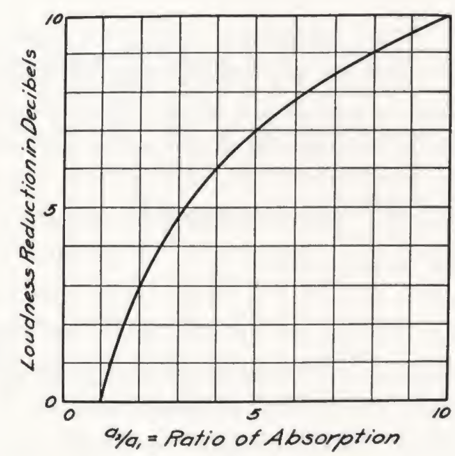
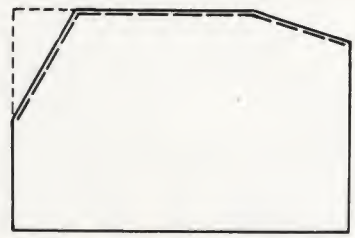


Figure No. 6

that effective quieting begins near this point. An extremely large amount of absorption is necessary to make the ratio of a_2/a_1, such amount that it gives a decibel reduction greater than 10. Compared to the amount of absorption necessary to give reductions



When treating a room for sound quieting, all sloping surfaces should be treated to prevent reflection and concentration of sound. The heavy dotted line indicates treatment.

between 5 and 10 decibels, a reduction of more than 10 decibels becomes somewhat uneconomical.

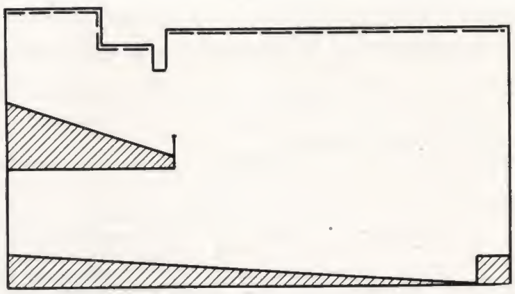
While 5 to 10 decibels reduction may seem small compared to the noise level of a room as indicated on the decibel chart, Figure No. 5, it is found in practice that this amount will cause a marked improvement in the noise conditions of a room.

Other factors are important

IN the comparatively simple room of rectangular shape, the needed amount of acoustical material may be applied at any place in the room where it fits the decorative scheme, and the results will be practically the same for the listeners.

In structures of complicated nature, such as theatres with their balconies and many curved or irregular surfaces, the problems of sound control become more involved. Curved surfaces, odd-angled walls, and various other elements of the complicated structure are liable to bring out sound concentration, "dead spots," and interference. Solution of these difficulties lies in placing acoustical material on the offending surfaces.

In auditoriums and other rooms of complicated structure, however, the need to decrease the reflection from some surfaces in order to eliminate echoes, "dead spots," or interference, forces some atten-



When the balcony ceiling extends upward to form a pocket, this area always should be treated to secure proper hearing conditions for persons in the balcony. The heavy dotted line indicates treatment.

tion to the subject of placing acoustical material to solve these special difficulties.

For completed buildings

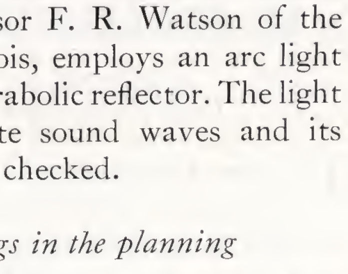
IN the structure already erected, it is not difficult to detect the offending surfaces by observation. A more accurate method, devised by Professor F. R. Watson of the University of Illinois, employs an arc light at the focus of a parabolic reflector. The light is used to simulate sound waves and its reflection carefully checked.

For buildings in the planning

IN the case of buildings that have not yet been built, a number of methods of detecting special acoustical defects are used. The oldest method is that of constructing the path of the sound, geometrically on sectional drawings. This method is obviously susceptible to error, although in skilled hands it is used successfully.

Unless the designer is thoroughly familiar with the use of a satisfactory test system, the services of a reliable independent acoustical consultant are best employed when the structure presents a difficult acoustical problem. Recommendations of the Acoustical Department of the Armstrong Cork & Insulation Company are furnished without charge.

Curved ceilings and curved surfaces in any part of the room always should be treated to properly dampen the reflected sound. The heavy dotted line indicates treatment.



Stage left reverberant

MUSICIANS find it desirable to play in an area more reverberant than good listening qualities will permit. Therefore it is best to place the acoustical material away from the stage in auditoriums and halls. This leaves the immediate area around the players more reverberant, yet does not affect reverberation period of the auditorium.

Noise factors in music rooms

"WHEN treating small music rooms for proper acoustics, it often happens that the problem of noise is overlooked," Vern O. Knudsen, points out in an article in the Journal of the Acoustical Society of America. "In the ideal music room, noise should be reduced to a level which is about as quiet as it is possible to maintain in a room with an audience, owing to such unavoidable noises as breathing, rustling of clothing, and moving in seats. Measurements in many existing concert halls and other music rooms reveal that noise from outside traffic, from the ventilating equipment, from the organ blowers, or from some other equipment in the building often reaches a level of 30 db. or more. Such noises are disturbing to both performers and listeners, and mark many of the more delicate tonal components which impart the finest quality to music. These problems of noise reduction are now placed on an engineering basis, and by suitable caution in selecting and designing, rooms can be constructed so that they will be free from noise."

The above photograph shows details of the decorative design secured with stencilled panels of Corkoustic in the auditorium of the Westminster Presbyterian Church, Decatur, Illinois. Architects—Brooks, Bramhall, and Dague, Decatur. General Contractor—Roy W. Christy.

ARMSTRONG'S ACOUSTICAL PRODUCTS MEET EVERY BUILDING NEED

These materials also provide high insulating value and increase decorative possibilities

ARMSTRONG'S Corkoustic is offered in three types to meet varying conditions encountered in acoustical and noise-quieting work, and possesses a number of unusually advantageous characteristics. It has been developed after extended research, approved by authorities on sound control, and has proved entirely successful and practical in hundreds of applications.

Corkoustic possesses a number of unusually advantageous physical characteristics among which are the following:

SOUND ABSORPTION EFFICIENCY: Types C and B in the one and one-half inch thickness have sound absorption values of 61% at a frequency of 512; Type A (for large areas) 32% in the one and one-half inch thickness at a frequency of 512.

Corkoustic Type A—This acoustical product provides a satisfactory and economical material for use where large areas are to be treated. It has a sound absorption coefficient of 32% in the one and one-half inch thickness at a frequency of 512. Rich warm brown in color, it is particularly appropriate for rooms that need dignity. It has proved entirely practical in many applications.

Corkoustic Type C—This new type of Corkoustic possesses, in the one and one-half inch thickness, a sound absorption coefficient of 61% at a frequency of 512. This new product has the pleasing light color of natural cork, and a texture that is attractive. The illustration on Page 8 shows an attractive installation of this new type of Corkoustic. Skilled workmen and trained supervisors are maintained by Armstrong for the erection of the Company's acoustical products.

Corkoustic Type B—Made by an exclusive new process, this new type of Corkoustic has the excellent sound absorption coefficient of 61% in the one and one-half inch thickness at a frequency of 512. This new acoustical product also is rich warm brown in color but has a texture slightly different from that of Type A. All types of Corkoustic can be decorated with washable paint.

Ceramacoustic—This is an entirely new type of acoustical material. It has an exceptionally high sound absorption coefficient—82% in the one and one-half inch thickness at a frequency of 512. Made of inorganic matter, Ceramacoustic is absolutely fireproof. Furnished in bevel-edged tiles, Ceramacoustic is pre-painted at the factory in three standard colors—white, ivory and buff. It also can be furnished painted with clear lacquer.

ATTRACTIVE COLOR: Colors range from the light color of natural cork (Type C) to the rich warm brown shades (Types A and B).

PLEASING TEXTURE: Each panel is individual, eliminating monotonous repetition of surface appearance.

HIGH INSULATING VALUE: Since all types of Corkoustic are made of cork, these acoustical products provide a high resistance to the passage of heat. They keep buildings warmer in winter, cooler in summer, and reduce fuel costs.

FIRE-RESISTANCE: Corkoustic has passed satisfactorily standard fire tests conducted by the University of Pennsylvania and the Massachusetts Institute of Technology.

DURABILITY: Furnished in strong, firm panels, Corkoustic is exceptionally durable. Due to the remarkable resistance of cork to moisture and its inertness to temperature fluctuations, Armstrong's Corkoustic does not buckle or warp.

HIGH LIGHT REFLECTION: All three types of Corkoustic provide high light reflection value when painted. Corkoustic Type C, because of its light color, provides an excellent light reflection value even when left in natural finish.

STRUCTURAL STRENGTH: The structural strength of Corkoustic is many times greater than is required to hold the panels true and rigid after being properly nailed or cemented in place.

EASE OF APPLICATION: Since Corkoustic panels are strong and firm, they are easy to apply. The units are light and easily handled.

DECORATIVE POSSIBILITIES: Decorative effects are limited only by the ingenuity of

School noises are effectively hushed in the Kindergarten Room at the Violetville School, Baltimore, Maryland, by a ceiling treated with painted Corkoustic. Architect—William F. Stone, Baltimore. General Contractor—Price Construction Company, Baltimore.

the designer. Pleasing effects may be secured by leaving the surface unpainted. All types of Corkoustic can be easily painted with washable paints.

Low Maintenance Costs: Corkoustic painted with Armstrong's Acoustic Paint may be washed with soap and water. Repainting can be done by spraying without changing the absorption value. Corkoustic painted with Alabastine can be wire-brushed and resprayed.

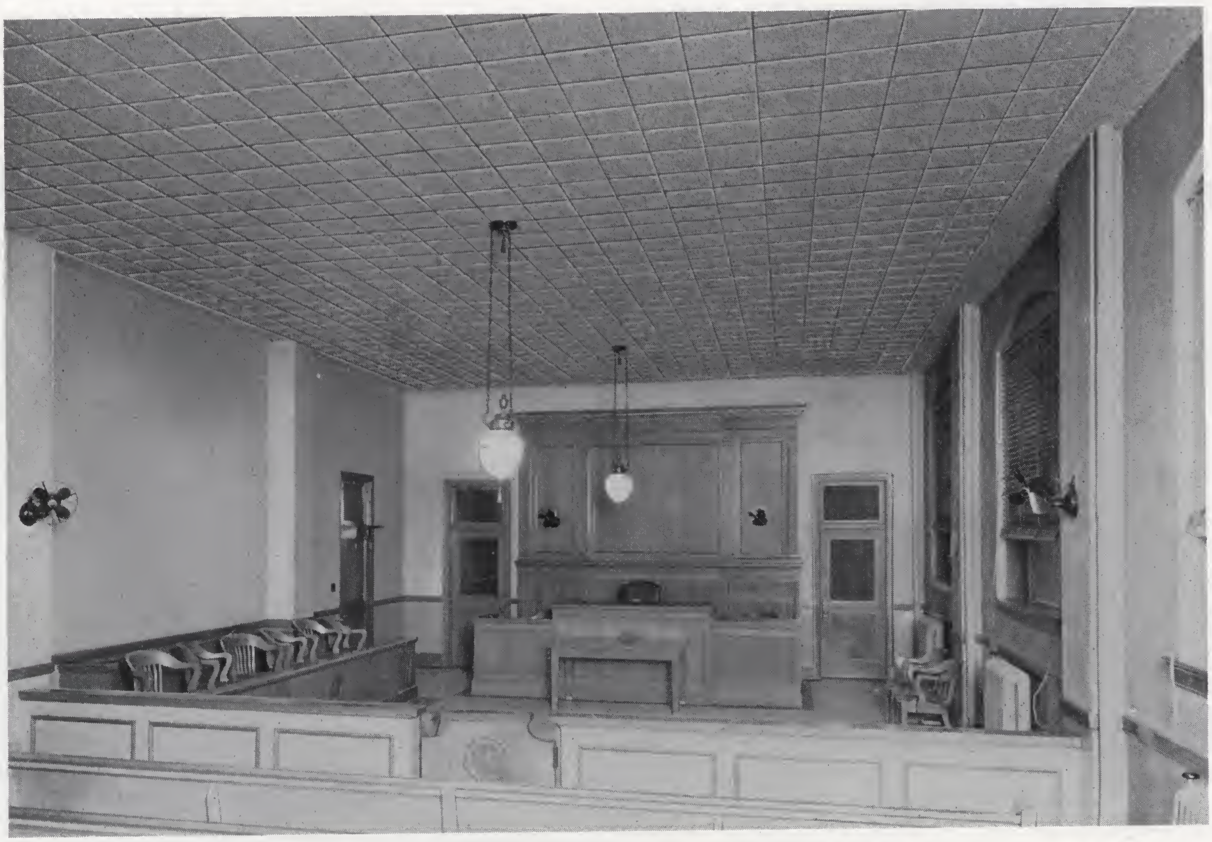
Corkoustic Rigidly Inspected

ALL types of Corkoustic are made of pure cork granules. All of the details of manufacture are so regulated that the material produced meets every requirement for sound control work. Rigid inspection is employed and only material that meets the highest standard is supplied on order.

CERAMACOUSTIC PROVIDES HIGH EFFICIENCY

CERAMACOUSTIC, an entirely new type of acoustical material, has a sound absorption coefficient of 82% in the one and one-half inch thickness at a frequency of 512. Because of its high efficiency, Ceramacoustic can be used effectively where the sound-absorbing units must be crowded into a relatively small wall or ceiling area. Made of inorganic matter, it is absolutely fireproof.

Furnished in bevel-edged tiles, Ceramacoustic offers an attractive interior finish. It is pre-painted at the factory in three standard colors—white, ivory, and buff. Ceramacoustic also can be furnished painted with clear lacquer. Economy is assured by low application and maintenance costs.



There's "order in the courtroom" here, where echoes and reverberations are eliminated by a ceiling of Corkoustic. The photograph shows the Harris County Criminal Courts Building, Houston, Texas, before spray paint was applied to the ceiling.

DECORATE ACCORDING TO YOUR OWN TASTE

THE decorative effects that can be obtained with Armstrong's Acoustical Products are limited only by the ingenuity of the designer. The wide range of size, surface, and finish makes the possibilities almost without limit, especially in view of the fact that surface decoration in color is thoroughly practical.

With natural colors ranging from the light buff of Corkoustic Type C and the rich warm brown of Types B and A to the creamy white of Ceramacoustic, a type of material may be chosen which is in close and pleasant harmony with the general decorative treatment.

Where desired, a pleasing decorative effect may be secured by combining painted and unpainted panels of Corkoustic.

Materials Can Be Spray-Painted

WHERE other colors are desired, they may be obtained by spray-painting the materials with Armstrong's Acoustic Paint. Attractive effects may be secured by the use of stencilled designs. The color possibilities, obviously, are unlimited and the medium is one that allows a wide range of technic. A particularly pleasing decorative effect can be obtained by painting the dark brown types of Corkoustic with a light over-all spray of Acoustic Paint. Light tints, contrasted by the dark interstices between the cork granules, give an effect very similar to sawed stone.

The beveled-edge units of the various types of Corkoustic provide for a simulation of masonry. They allow for a wide variation in pattern. The masonry effect is enhanced by the fact that the panels of Corkoustic are laid in place with broken joints.

Painting Does Not Reduce Efficiency

SPRAYING these acoustical products with Armstrong's Acoustic Paint does not affect their sound-absorbing capacity. Tests show that the coefficients of absorption remain practically the same after the paint has been sprayed on.

Paint Increases Light Reflection Factor

CORKOUSTIC Type C has a relatively high light reflection factor when left in

Corkoustic serves as insulation as well as acoustical treatment in the dining hall of the Alpha Delta Phi Fraternity house at the University of Rochester, Rochester, New York. Architects—Bohacket and Brew. General Contractor—John Garrett.

natural finish. When painted with Armstrong's White Acoustic Paint all types of Corkoustic have an exceptionally high percentage of light reflection. Where indirect lighting is necessary, the various types of Corkoustic, as well as Ceramacoustic, give most satisfactory results when painted in this manner.

Light Reflection Table

THE following table gives the light reflection factors of Corkoustic, for both the natural color and painted panels:

Trade Name	Description	Reflection in per cent
Corkoustic	Choc. br., natural colors	8.3
Corkoustic	White	66.0
Corkoustic	Cream (Alabastine #26)	70.9
Corkoustic	Tan (1—#26, 1—#48)	49.2
Corkoustic	Tan (3—#26, 2—#48)	46.9
Corkoustic	Tan (2—#26, 1—#48)	53.2
Corkoustic	Tan (3—#26, 1—#48)	53.2

National Lamp Works of the General Electric Company, Nela Park, East Cleveland, Ohio.

CONDENSATION IS PREVENTED

CORKOUSTIC Types A and B serve exceptionally well as a noise-quieting treatment for swimming pools. It not only reduces noise but also checks condensation and ceiling drip which are particularly objectionable. This is particularly important from the standpoint of sanitation as well as from the fact that pools which have not been protected with an insulating material require more frequent cleaning. Deterioration of the roof structure is prevented, too, since Corkoustic prevents moisture from condensing on the under side of the roof, and thus eliminates roof rot and rusting of steel.

Since Corkoustic has high insulating efficiency, use of this acoustical material insures a saving in heating costs and the additional comfort and health benefits resulting from a more constant temperature.

An atmosphere conducive to quiet study is assured at the Hauser Memorial Library at Reed College, Portland, Ore., by a ceiling of Corkoustic. Architects—A. E. Doyle Associates. Contractors—Lorens Brothers.

MAKE YOUR OWN SELECTION
of Sizes, Surfaces, and Finishes

ARMSTRONG'S Corkoustic Types C, B, and A are available in the following standard sizes: 6″ x 12″, 12″ x 12″, 12″ x 18″, 12″ x 24″, 12″ x 32″, 12″ x 36″, and 24″ x 24″. Corkoustic Types A and B are available in three thicknesses—1″, 1½″, and 2″. Type C is furnished in the 1½″ thickness.

The larger Corkoustic units can be furnished with bevel grooves through their surface, giving the finished application the appearance of being made from smaller units and providing opportunity for a number of interesting designs.

All types of Corkoustic are furnished in beveled panels with sanded surface. Sanding gives the various types of Corkoustic an especially interesting surface texture.

Since each panel is individual, monotonous repetition of surface appearance is eliminated, assuring a wall and ceiling treatment that is pleasing and distinctive.

It is possible to manufacture Corkoustic in special sizes other than those listed above when necessary. Before planning the use of special sizes, we advise that you communicate with the nearest branch of the Armstrong Cork & Insulation Company in order to determine the practicability of manufacturing the unit desired.

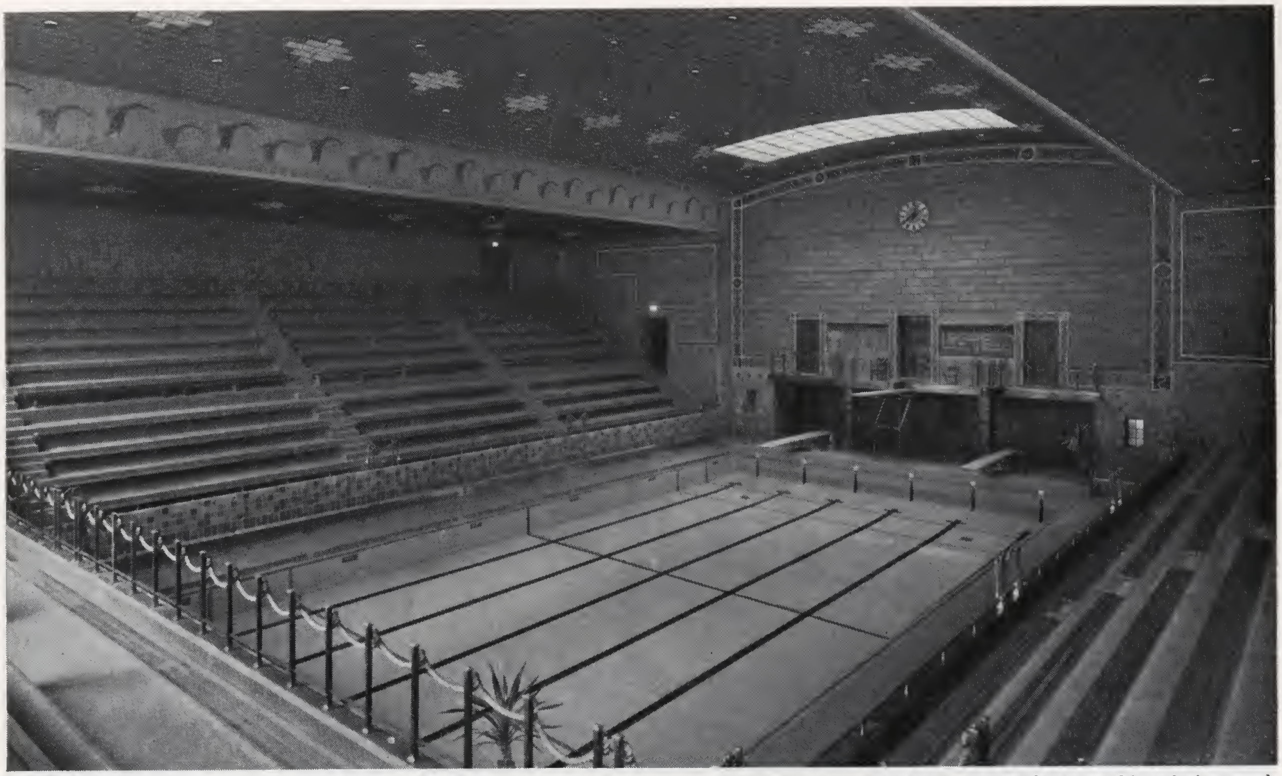
Sizes of Ceramacoustic

CERAMACOUSTIC is furnished in standard tiles 9″ x 4½″, 6″ x 6″, 6″ x 12″, 12″ x 12″ in 1⅛″ and 1½″ thicknesses with beveled edges. Special sizes can be manufactured.

The natural warm brown of Corkoustic provides a harmonious decorative effect as well as ideal acoustical conditions in the auditorium of the Junior High School, Decatur, Ill. Architects—Brooks, Bramhall, and Dague, Decatur.

Tests referred to on Page 5 of this booklet indicate that 19% less energy is consumed by a typist when working under quiet rather than noisy conditions. Output of work also is increased when offices are treated with Corkoustic.

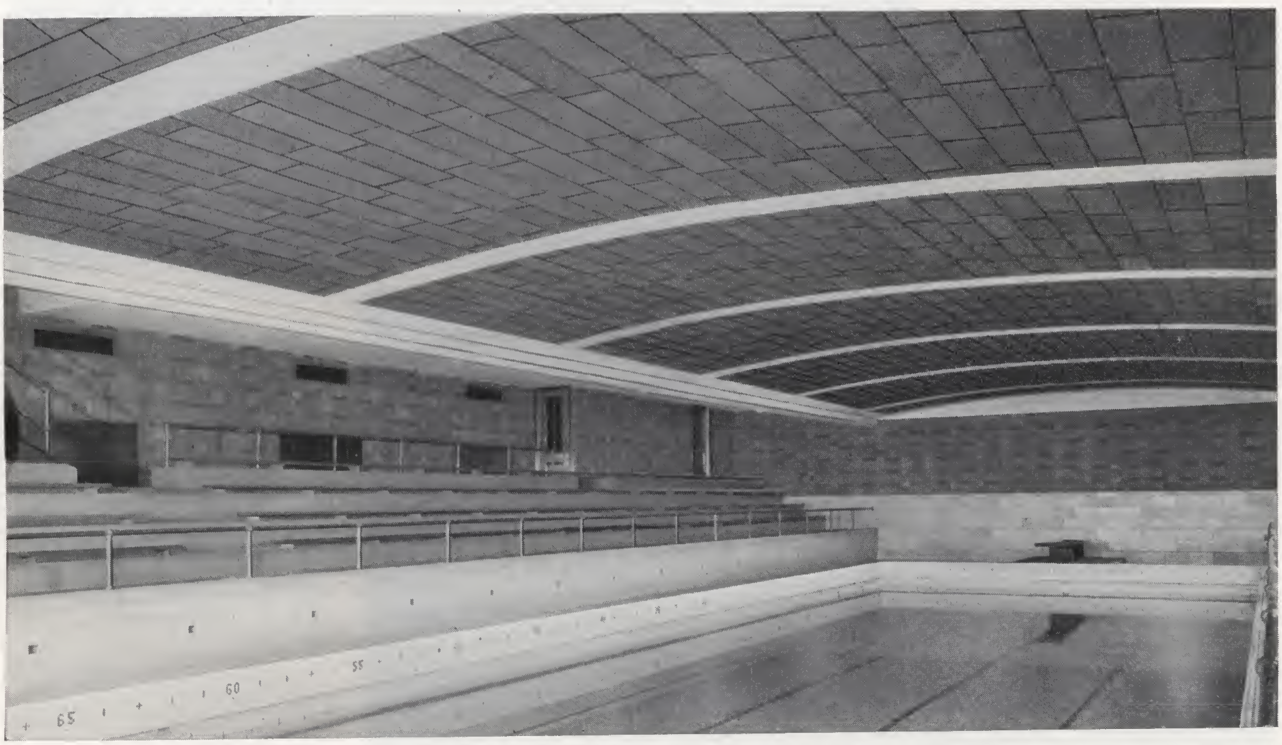
A ceiling of Corkoustic in the dining-room of the Illinois Women's College, Jacksonville, Ill., protects diners from annoying disturbances. Corkoustic also serves as an insulation against heat and cold. Architects—Royer, Danley & Smith, Urbana, Ill.



Ohio State University installed Corkoustic in its new Natatorium Building to eliminate unwanted noise, provide thermal insulation, and a decorative finish. Corkoustic also was used in the University's new Physical Education Building. Architect—Howard Smith, Columbus.

The gymnasium and locker rooms, as well as the swimming pool at the College of New Rochelle, New Rochelle, New York, have been quieted with Corkoustic. Architect—Henry J. McGill, New York. General Contractor—M. Bartnett and Sons, New Rochelle.

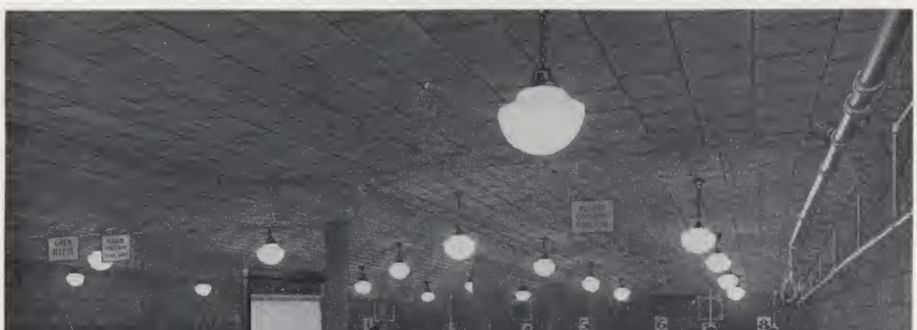
A restful atmosphere aids patients to recover at the Philipsburg State Hospital, Philipsburg, Pennsylvania where ceilings of corridors and private rooms are treated with Corkoustic Type C. Painted with Armstrong's Ivory Acoustic Paint, the Corkoustic can be easily cleaned.



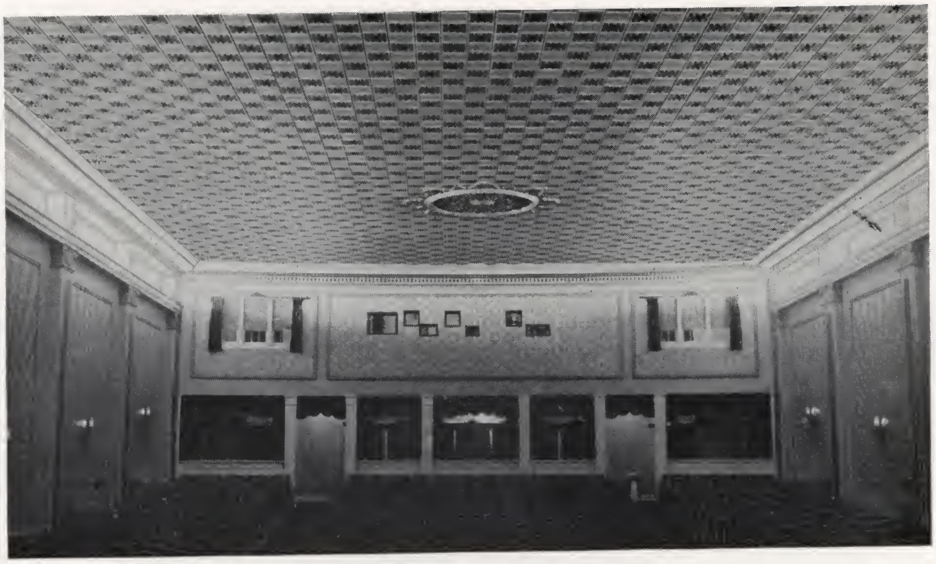
The Connelly Trade School Natatorium, Pittsburgh, Pa., is treated with Corkoustic to muffle noise and prevent condensation. With this ceiling treatment reverberations are quickly absorbed. Architect—E. B. Lee, Pittsburgh.

A Corkoustic ceiling helps make the cafeteria of the Connelly Trade School, Pittsburgh, a pleasant place to dine. Architect—E.B.Lee.

Booming echoes and distracting noises are satisfactorily eliminated in this natatorium at the N. E. Branch Y. M. C. A. at Detroit, Michigan. Architects and Engineers—Smith, Hinchman & Grylls. Contractor—Albert A. Albrecht.



That even the clamor of bowling alleys can be subdued was demonstrated when the Capital Lyric Theatre Bowling Alleys at McKeesport, Pennsylvania, were treated with Corkoustic.



Acoustics are ideal in the Lincoln Theatre, Robinson, Ill. Stencilled panels of Corkoustic were applied on the entire ceiling. Architects—Kennerly & Stiegemeyer, St. Louis. Contractor—L. & W. Scherhekan.

This is one of the private rooms at the Philipsburg State Hospital, Philipsburg, Pennsylvania, treated with Corkoustic. In this cheery room, the Corkoustic was painted with Armstrong's Ivory Acoustic Paint.

Corkoustic prevents annoying echoes in this pleasant classroom of the Barnum Elementary School, Denver, Colo. Architect—E. Floyd Redding, Denver. Contractor—M. E. Carlson, Denver.

INSTALLATION DATA
for Armstrong's Corkoustic and Ceramacoustic

METHODS OF APPLICATION

Three methods are used in the application of Corkoustic and Ceramacoustic. Corkoustic may be easily and economically installed by any of the three but only the latter two are suited for the installation of Ceramacoustic.

Where possible 1½″ thick Corkoustic and Ceramacoustic is suggested for use. Other thicknesses may be used, however, depending on conditions and the treatment desired.

The design to be followed in the installation of acoustical materials shall be selected by the architect. Standard sizes of Corkoustic and Ceramacoustic and suggested patterns for installation are shown elsewhere in this booklet.

Supporting members, such as furring strips, furring channels, suspension rods, etc., should be based on the weight of finished acoustical materials in accordance with the table below:

Material	Thickness	Weight Per Sq. Ft. Lbs.
Corkoustic, Types A and B	1″	.70
	1½″	1.05
	2″	1.40
Corkoustic, Type C	1½″	1.60
Ceramacoustic	1⅛″	3.50
	1½″	4.70
	2½″	7.80

1—Furring Method: The areas that are to be acoustically treated shall be furred with wood strips fastened securely to the structural surface. The wood furring strips should be treated against decay and be fire resistant. The spacing and the direction of the furring strips shall be arranged to accommodate the design and characteristics of the acoustical treatment, but should not be farther apart than 12″ on centers. The acoustical material is fastened to the furring strips with nails. This method permits considerable latitude in the application of acoustical materials to the various types of ceiling and wall constructions encountered in old and new buildings.

The furring method is adaptable only to Corkoustic. Ceramacoustic cannot be erected by the furring method.

Size of furring strips and method of securing them in place should be based on the weight of finished Corkoustic as given above.

2—Cement Method: The acoustical material is bonded directly to the structural surface with a special waterproof adhesive. Particular attention must be given to the condition of the structural surface, as any unevenness or roughness in it will appear in the finished surface of the acoustical treatment. Uneven or rough surfaces can be put in proper condition with plaster, in which case only the brown coats, brought to a true and even surface and trowelled smooth, are required, the white or finish coat being omitted.

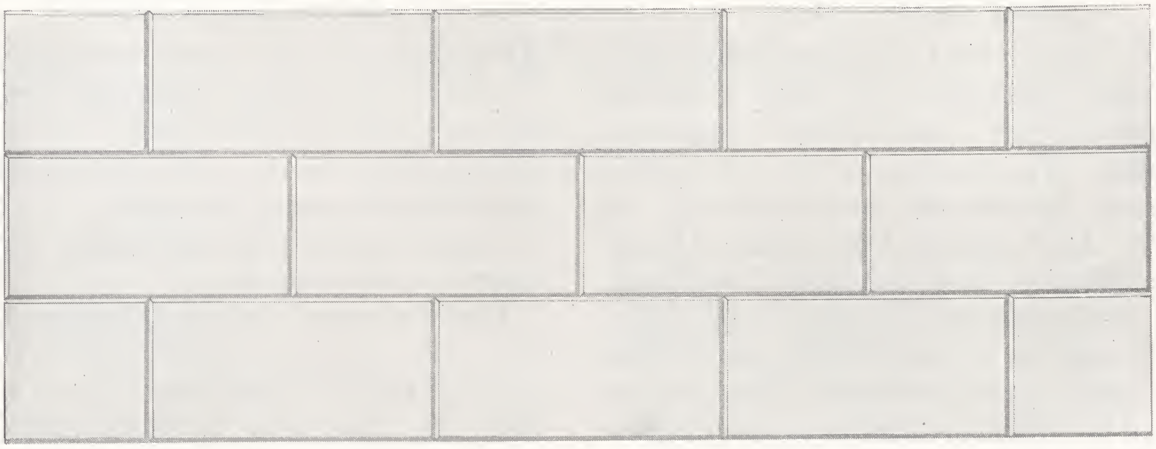
This method of application can be used for Corkoustic or Ceramacoustic.

3—Mechanical Method: A mechanical system composed of several special structural members is fastened to or suspended from the structural surface and in turn supports and reinforces the acoustical treatment. It eliminates the necessity for intermediate constructions and can be installed without regard to the condition of the structural surface. It is a permanent fireproof construction; is compact, occupying a maximum space of 2¼″ when using 1½″ thick acoustical material. It is equally suitable for wall and ceiling treatments, and permits considerable latitude in the application of acoustical materials to the various types of ceiling and wall construction encountered in old and new buildings.

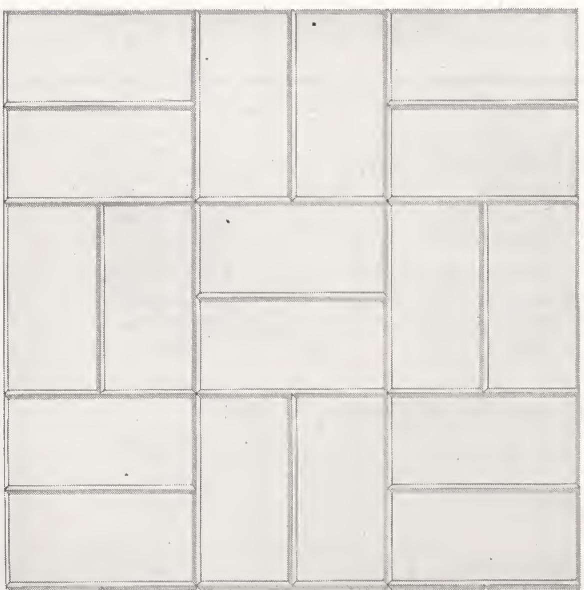
The mechanical method is adaptable to either Corkoustic or Ceramacoustic.

The mechanical method may be secured directly to existing walls and ceilings, but on new work the metal lath and plaster may be omitted from ceiling or wall areas to be acoustically treated. The furring channels ordinarily provided for the support of the metal lath and plaster shall be put in place at the proper height to provide for the attachment of the acoustical materials by the mechanical method. The method of securing and suspending these channels should be based on the weight of finished Corkoustic and Ceramacoustic as given above.

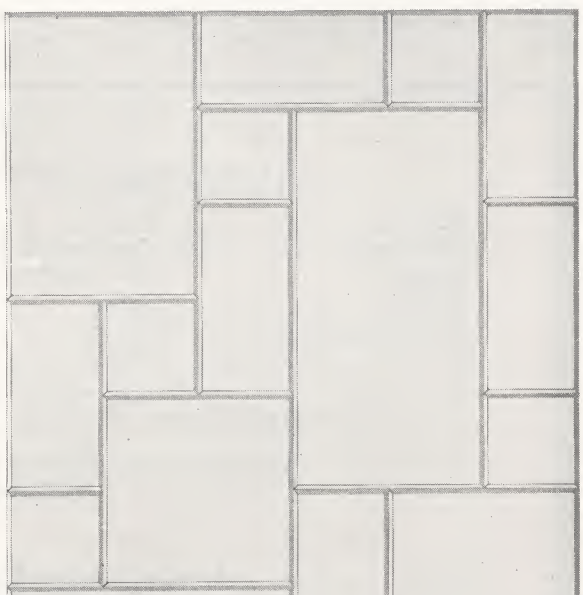
SUGGESTED ARRANGEMENTS OF CORKOUSTIC AND CERAMACOUSTIC



A commonly used arrangement of units of acoustical materials laid up with broken vertical joints. Such a design may be developed from a wide variety of Corkoustic and Ceramacoustic units depending on the character desired.



An interesting surface pattern that may be made from 6" x 12" Ceramacoustic, depending on the texture desired.



One of the effects that may be secured by laying up Corkoustic of random shapes. The variety is almost endless.

ARMSTRONG'S SERVICES
and where to get them

Free advisory service

THE Armstrong Cork & Insulation Company maintains at all times a staff of experts to assist in the solution of acoustical problems. The facilities of the Company's research laboratories are constantly in use by the Acoustical Department. The information and data that have been gathered from a number of years of such study will be applied to any problem upon which you may desire assistance. There is no charge or obligation for this service. Either write to Armstrong Cork & Insulation Company, Acoustical Department, Lancaster, Pa.; or get in personal touch with the nearest Armstrong branch office.

Expert contract service

IT is important, of course, that the application of Armstrong's Acoustical Products be made carefully and correctly. No matter how excellent the material, its performance will always be materially better if it is installed competently. For this reason we offer expert contract service.

The Armstrong Cork & Insulation Company will contract to install acoustical materials. Skilled workmen and trained supervisors are maintained by the Company for this work. Ask the nearest branch office to give you complete information about Armstrong's expert contract service or write to the home office at Lancaster, Pennsylvania.

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San Francisco, Cal., Van Fleet-Freear Co.
Seattle, Wash., Tourtelotte-Bradley, Inc.
Washington, D. C., John R. Livezey

THE ARMSTRONG LINE

THE Armstrong Cork Company and its subsidiaries have eleven domestic factories located at Camden, Gloucester, and New Brunswick, N.J.; Fulton, N.Y.; Pittsburgh, Oakdale, Beaver Falls, two at Lancaster, Pa.; Greenville, S.C., and Pensacola, Fla.; six factories in Spain; and more than thirty cork-baling and receiving stations abroad. Following is a list of the principal products.

Insulation Division Products

HIGH TEMPERATURE INSULATION

Armstrong's Insulating Brick and Nonpareil Insulating Brick for industrial furnaces and other high temperature equipment.

LOW TEMPERATURE INSULATION

Armstrong's Corkboard for insulating cold storage rooms, walls and roofs of commercial and public buildings, and residences, refrigerator cars, commercial display cases, refrigerators, tank cars, and trucks.
Armstrong's Cork Covering for refrigerated drinking water systems, brine, ammonia, and all cold lines.

OTHER PRODUCTS

Armstrong's Corkoustic and Ceramacoustic for noise-quieting and acoustical correction.
Armstrong's Vibracork for absorbing vibration and reducing noise in all types of machinery.
Armstrong's Temlok for roof, refrigerator, and equipment insulation.
Armstrong's Temlok Building Insulation for sheathing, plaster base, and interior finish.
Circle A Cork Brick for floors of dairy barns and hog and poultry houses.
Armstrong's Airproofing, a plastic material for airproofing insulating brick, fire brick, red brick, and other materials and for weatherproofing materials exposed to the elements.

Floor Division Products

Armstrong's Linoleum: Plain, Jaspé, Inlaid, Embossed, and Printed.
Armstrong's Linotile for offices, banks, etc.
Armstrong's Cork Tile for bathrooms, libraries, museums, churches, schools, etc.
Armstrong's Accotile (asphalt type).
Armstrong's Rubber Tile.
Armstrong's Inlaid Linoflor.
Armstrong's Aeroflor
Armstrong's Cork Carpet.
Armstrong's Quaker Rugs and Floor Covering.
Armstrong's Standard Rugs and Floor Covering.
Armstrong's Cove and Base—Linoleum, Linotile, Cork Tile, Accotile, Rubber Tile.
Armstrong's Linowall
Armstrong's Lining Felt.
Armstrong's Linoleum Paste and Cement.
Armstrong's Linoleum Lacquer.
Armstrong's Linogloss Wax.

Cork Division Products

FOR AUTOMOBILES AND OTHER MACHINERY

Armstrong's Cork Gaskets; Armstrong's Gasket Cement; Armstrong's AutoMat and Armstrong's Linoleum for covering running boards; Armstrong's Glazing Strip for setting glass and silencing body noises; Body Shim; Anti-Squeak; Cork Floats; Oil and Grease Retainers; Washers and Discs; Valve Seats; Noise and Shock Absorbing Pads and Cushions; Friction Rolls; Pulleys; and Blocks.

CLOSURES FOR BOTTLES, JARS, ETC.

Armstrong's Corks; Armstrong's Crown Caps; Armstrong's Embossed Top Corks; Armstrong's Rubber Stoppers; Armstrong's Artmold Caps and Jar Covers; Armstrong's Artmetal Caps; Cel-O-Seal Caps and Bands; Armstrong's Metal Caps; Applicators; Bungs (cork and wood); Shoe Swabs; Plugs and Corks of all kinds.

FOR MARINE PURPOSES

Armstrong's Life Preservers; Gill, Seine, and Mullet Corks; Mooring Buoys; Ring Buoys; Yacht Fenders.

FOR TEXTILE MILLS

Armstrong's Gridded Cork Ribbon for Silk Loom Take-Up Rolls; Armstrong's Seamless Cork Cots for Cotton Spinning and Card Room Rolls; Armstrong's Cork Covers for Worsted Mill Rolls; Armstrong's Cork Temple Rolls for Silk Looms; Armstrong's Cork Covers for Silk Throwster Rolls; Armstrong's Cork Composition for Loom Brakes.

FOR SHOE MANUFACTURING

Armstrong's Cork Box Toes; Armstrong's Bottom Filler; Armstrong's Cork Counters; Ground Cork; Heel Pads; Insoles (full and half); Korxole; Lifts; Linosole; Sheet Cork.

FOR MISCELLANEOUS USES

Bath Mats; Table Mats; Cork Balls; Churn Strips; Entomological Sheets; Pen-holder Tips; Plasterers' Floats; Polishing Wheels; Ribbon Cork; Handles of all sorts; Ground Cork; Laboratory Rings; and hundreds of other Cork Specialties of all kinds.

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Armstrong's

A

Product